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IMPROVING SHIPYARD PRODUCTIVITY THROUGH THE COMBINED USE OF PROCESS ENGINEERING AND INDUSTRIAL ENGINEERING METHODS ANALYSES TECHNIQUES

TOMMY L. CAUTHEN

INGALLS SHIPBUILDING

PASCAGOULA, MISSISSIPPI

ABSTRACT

Despite the obvious compromises to efficiency that must be made when producing small quantities, the shipbuilding industry sometimes rules out or fails to consider some of the efficient techniques and methodologies of mass production manufacturing.

In this paper a comparison and contrast is made between the methods of mass production and small quantity manufacturing. Also revealed in this paper are the benefits from the use of a mass production process engineering technique and a methods analysis technique during the performance of the National Shipbuilding Research Program's SP-8 panel Task E-8-21. The use of a mass production process engineering technique (using tool routings to provide a summary of all of the tools, gages, etc. required to operate and control the products being produced from mass production machining and assembly equipment) is explained as a solution to a methods problem of excessive travel for tools in shipboard equipment machining and installation by Outside Machinists. The paper concludes with a promotion of this specific application of mass production methodology in shipbuilding and a promotion of the re-evaluation of mass production techniques by shipyards as a vehicle for productivity improvement.

Improving Shipyard Productivity Through Process Engineering And Industrial Engineering Techniques

INTRODUCTION

There is growing concern in the U. S. shipbuilding industry about productivity. This concern is caused by the inability of U. S. shipyards to compete with foreign shipbuilders in the market for construction of commercial ships and by the decline in U. S. Naval ship construction contracts over recent years. Both of these problems put many U. S. shipyards in a position of literally fighting for existence. In an effort to increase productivity, the U. S. shipbuilding industry has, for example, made improvements to shop facilities, investigated the use of robotics, re-evaluated support labor requirements, and utilized CAD/CAM computer Aided Design/Computer Aided Manufacturing) technology. All of these activities are worthwhile endeavors. However, most of these productivity programs have little or no impact upon onboard ship construction. Not enough is being done oh a consistent basis to improve the productivity of the machinist, pipefitter, welder etc. who is working on the ship.

The U. S. shipbuilding industry needs to make a re-evaluation of the entire current system of basic ship construction being employed in America. Even the Japanese shipbuilding techniques, which have been investigated by U. S. shipbuilders, are actually sound principles of industrial engineering methods analysis as applied to shipboard work.

The principles of methods analysis have worked well over the years as a labor cost reduction tool in the mass production environment. However, the traditional mass production principles of industrial engineering methods analysis need creative adaptation to obtain productivity improvements in the onboard ship environment.

MASS PRODUCTION VERSUS SMALL QUANTITY MANUFACTURING

The basic difference between mass production and small quantity manufacturing is the number of units produced during a given time frame. In mass production, a large number of identical units are manufactured over a relatively short time frame. An obvious example of mass production is the manufacture of a popular American automobile model whose volume would exceed one million units per year. The mass production repetition has two important advantages. First, a worker quickly reaches the point on the learning curve where virtually no more learning can occur. Thus, the unit cost is at its lowest possible point. Secondly, it becomes feasible to perform a detailed method analysis on each direct labor function to uncover any inefficiencies in the production methods and to foster productivity improvement in mass production.

In small quantity manufacturing, a small number of identical units are manufactured over a relatively long time frame. An example of this would be the manufacture of ten ships over a five year period. The lack of repetition in small quantity manufacturing has two major disadvantages in the area of efficiency. First, a worker never reaches the point on the learning curve where no more learning can occur. Thus, the unit labor

cost is very high when compared to mass production. Secondly, in small quantity manufacturing, the performance of detailed methods analysis of each labor function is not as feasible as it is in mass production. However, this article will present evidence to prove that proper application of methods analysis techniques can be quite advantageous, even in the construction environment onboard a ship.

EXAMPLE: A TOOL LIST PROGRAM

Background

In December of 1983, Ingalls Shipbuilding began to perform the National Shipbuilding Research Program (NSRP) Task ES-8-21, the Data Development of Detail Standards for Outside Machinery Operations. During this project, time standards were developed for outside machinery equipment installation using the Maynard Operation Sequence Technique (MOST), a predetermined motion time system. The purpose of this project was twofold. It was primarily to provide the shipbuilding industry with a set of universal standards for outside machinery operations. It was also to identify specific areas where methods improvements could be made to benefit both Ingalls Shipbuilding and the U. S. shipbuilding industry.

During the shipyard observations by methods analysts, the problem of excessive travel for tools by outside machinists became apparent. Methods analysts discovered that some machinists were reporting to shipboard job sites without all of the tools required to perform the job. Numerous trips were made off of the ship for additional tools. Further analysis revealed that correction of the problem would save Ingalls Shipbuilding

over $300,000 annually in direct labor cost for excessive travel alone. Communications with other shipyards through NSRP SP-8 Panel on Industrial Engineering revealed that the problem was industry wide.

Realizing that the problem was industry wide, Ingalls Shipbuilding submitted a proposal that was approved by the SP-8 Panel to implement and evaluate a solution to this problem. The proposed solution was to provide machinists with tool lists that would enumerate all of the necessary tools required to perform each job. The idea for this proposed solution was extracted from the mass production process engineering technique of using routing sheets. The routing sheet is used to list the machines or tooling required to produce a part.'

Program Advantages

This tool list program's primary objective and major emphasis is on the elimination of excessive travel to obtain tools by outside machinists. However, the benefits of this program are not limited solely to reduction in excessive travel for tools. There are additional benefits that can be obtained from a tool list program. The following is a list of these additional benefits.

1. A comprehensive list of the tools required to perform specific tasks can be provided as a training aid for apprentice machinists.
2. By providing a comprehensive list of tools required to perform a task, a tool list program reduces the amount of time an experienced machinist would have to spend planning the performance of a task.

3. If the tool lists are stored in a computer, the tool list program can provide tool room personnel with a schedule and detail listing of the tools required during a given time frame. The list can assist in forecasting tool requirements with accuracy.

Application

The outside machinist supervisor is the backbone of a tool list program. Without his cooperation a tool list program will not be worth the paper the fool lists are printed on. The supervisor must encourage and monitor the use of the tool list program by his employees. if he does not, the chief objective of the program will not be realized--the elimination of excessive travel. Therefore, to insure the success of a tool list program, the supervisor's participation in the program from its inception is essential. Ideally, the supervisor should be able to feel that it is his program even if it was not originally his idea.

> IT has been said that the perfect staff work can be identified easily because the recipient of the staff work finds it difficult to identify the role of the staff helper and differentiate it from his own role in the solution of the problem....[2]

One way to get the supervisor' to participate in the program is to have him develop the tool lists. This way the tool list becomes his own work and, thus, he will become its greatest proponent.

If the supervisor is too preoccupied to develop detailed tool lists, someone else should develop them and the supervisor should review them for accuracy.

The next steps are to determine which areas of the shipyard to use the tool list concept and if the program is economically feasible for a given ship construction contract. The most obvious place to start using a tool list program is with shipboard equipment installation utilizing the ship series production concept. Series production is defined as the production of a series of nearly identical ships.[3]

In the case of series production, once the tool lists have been developed, only the minimal cost of maintaining the tool list program is incurred after the first ship. To determine economic feasibility of a tool list program, an evaluation of the associated administrative costs and cost savings must be made. In the proceeding analysis, the payback period Will be used to make the evaluation of a typical program's economic feasibility.

Payback Analysis

The details of a payback analysis based on information obtained from an actual tool list pilot program implemented at Ingalls Shipbuilding is shown in Tables 1 and 2.[4] This particular tool list program involved the construction of Ticonderoga (CG-47) Class cruisers built in series. The administrative costs are shown in Table 1. Also shown in Table 1 are the organizations involved within the company and the scope of their activities as they relate to the tool list program.

TABLE I - TOOL LIST PROGRAM

ADMINISTRATIVE COST

ADMINISTRATIVE IMPLEMENTATION COST	
- COMPUTER SERVICES (Computer Usage)	$ 1,035
INDUSTRIAL ENGINEERING (Coordination and Tool List Development)	76,125
OUTSIDE MACHINERY (Review Tool List Development)	8,760
TOTAL	$85,920
ANNUAL ADMINISTRATIVE OPERATING COST	
COMPUTER SERVICES (Computer Usage)	$ 1,421
OUTSIDE MACHINERY (Changes and New Equipment)	876
PRODUCTION PLANNING (Tool List Added to BOM)	7,597
REPROGRAPHIC SERVICES (Additional Paper Generated)	165
TOTAL	$10,059

Table 2 shows the payback period calculation. The annual operating cost is subtracted from the gross annual savings to yield a net annual savings. The implementation administrative costs are considered as an investment cost which is divided into the gross annual savings to yield a payback period of 27 years.

Although the feasibility of the tool list concept must be evaluated based on the particulars of each shipyard's product mix, this basic thesis has been proven by this example: the tool list concept is economically advantageous for nearly identical ships built in series.

Program Description

This tool list program was designed to provide the maximum amount of information to the craftsman with the intention of holding the administrative cost of the program to a minimum. The highlight of this program is that the tool list is printed on the bill of material kitting report. Use of this system provides a complete summary of both tools and materials required to complete a given job. The mechanics of this program and the departments involved are shown in Figure 1.[5] First , an industrial engineer develops the tool lists and an outside machinery supervisor reviews them for accuracy. An industrial engineer then stores the tool list in the Technical information Data Base (TIDB) Text System. The industrial engineer also develops an Account and item to Tool List Code Matrix to identify the location of each tool list in the computer as shown in Table 3. The planner then uses the matrix to match each major piece of equipment on a bill of material kitting report to a tool list code number. The tool list code number, kitting report number, and hull

TABLE 2

TOOL LIST PROGRAM PAYBACK ANALYSIS

Gross Annual Savings	$323,651
Less Annual Administrative Operating Cost	-10,059
Net Annual Savings	313,592
INVESTMENT (Administrative Implementation Cost)	$85,920
PAYBACK PERIOD	0.27 YEARS

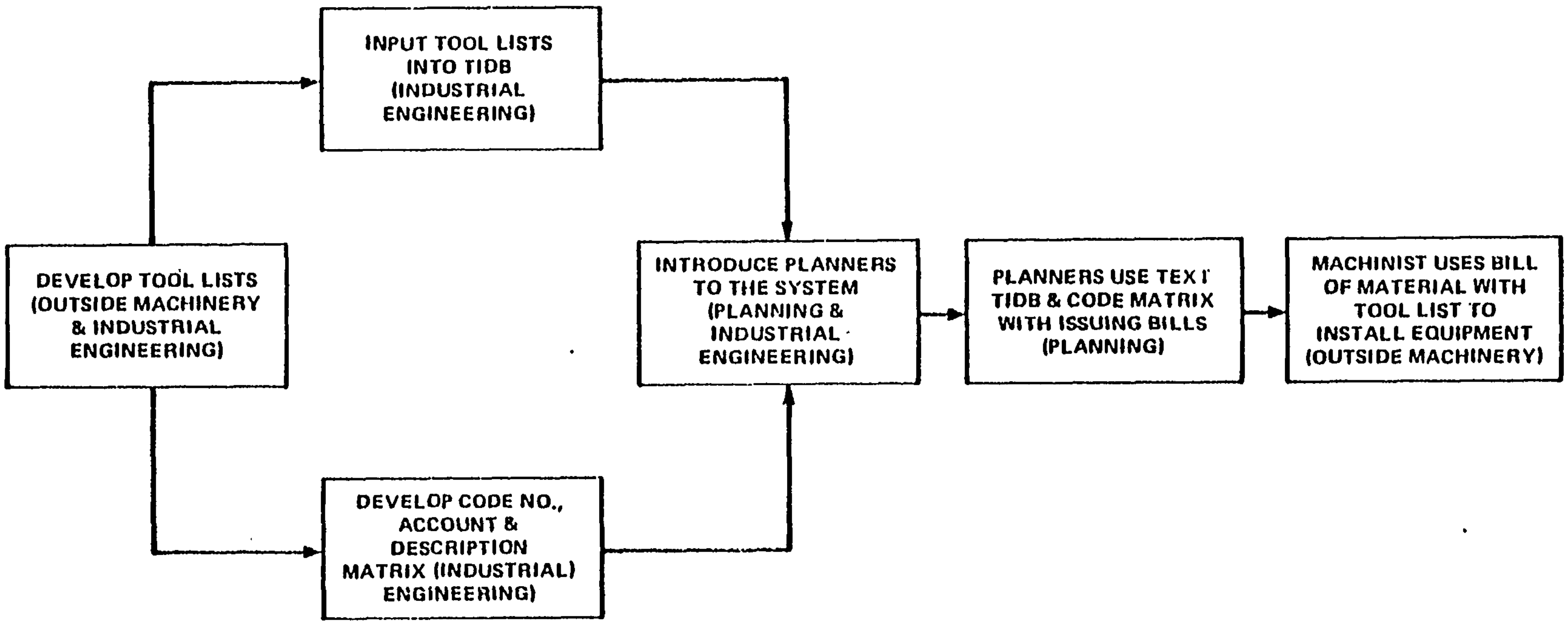

FIGURE 1 TOOL LIST PROGRAM NETWORK DIAGRAM

TABLE3- SAMPLE ACCOUNT AND ITEM TO TOOL LIST CODE NO. MATRIX

ACCOUNT NO.	ITEM DESCRIPTION	TOOL LIST CODE NO.
2501'	BELLMOUTH	0100
2501	COOLING COIL	0101
2501	PRECIPITATOR	0102
2501	FAN COIL ASSEMBLY	0103
2.501	POWER PACK	0108
2.501	TOXIC GAS DAMPER	0107

identification number is typed into the TIDB Text System by the planner. The computer then generates a bill of material kitting report with a tool list attached as shown in Figure 2. Now the machinist can gather all of the necessary tools and materials to complete a job by referring to one document.

THE COMPUTER INTERFACE

The computer interface is with the TIDB Text System. The TIDB Text System is a computer program written by Ingalls Shipbuilding Information Systems Department for the express purpose of adding notes to the bill of material kitting report. These notes provide supervisors and workers with information that would assist them in ship construction. The five available options of the TIDB Text System are as shown in Figure 3. Option number one allows tool list data to be input, changed, or removed from the computer; thus, the actions create/modify/delete. The tool list data was input into the computer under a dummy bill of material kitting report number **(0000-000-1)** and a dummy bill hull,identification number (4500). The second option, Detail Text View, allows the data that has been input from option number one to be viewed. Option number three, Merge paragraph from existing bill, allows the tool list information stored on the "dummy" bill of material kitting report to be transferred to the bill of material kitting report that the tool list data is-applicable to. Option number four, Bill Paragraph List, displays the paragraph numbers (tool list code numbers) on any given bill of material kitting report. Option "X" allows one to end the session of interaction on the program.

```
                       BILL REV:                        INGALLS SHIPBUILDING       MATL CODE: ___       CHANGE REASON: ________
DATE: 03/28/85 02:40   BILL: 2501-236-1    HULL: 4504   DESC: VEHE EQUIP MOD 4 ASSY 404                    REPORT NO. : X83352-R1
DEPT: P P & S          REQD-DT: 091084   DISIR: N         KITTING REPORT              BILL PAGE NO:     1      RPT PAGE NO:      693
SCHED ISS: 081384 ACT ISS: 073084 LATEST CHG: 000                              'LEAD DP: 24 ASSIST DP: 77       WORK STA NO: 590

                                                                                              ************************
                                                                                              * PLANNER: __________  *
                                                                                              *                      *
                                                                                              *    DATE: - / / -     *
                                                                                              *                      *
                                                                                              *COMPLETE:    Y,    N- *
                                                                                              ************************

PARA      < < < ------------------ TEXT ------------_---------- > > >

0104      ***********************************************************************
          *                       OUTSIDE MACHINERY                             *
          *                     VENTILATION EQUIPMENT                           *
          *                         TOOL LISTING                                *
          *                                                                     *
          * DESCRIPTION:        FAN COIL UNIT                                   *
          *                                                                     *
          * SPECIFICATIONS: MODEL            H1-H8 & V7                         *
          *                 HEIGHT           265-805 LBS.                       *
          *                 FDN BOLT SIZE    5/8 IN.                            *
          *                                                                     *
          *                                                                     *
          * (A) TOOLS REQUIRED FOR INSTALLATION WHEN LINERS AREN'T              *
          *     NECESSARY INCLUDE:                                              *
          *                                                                     *
          *     BALL PEIN HAMMER    DRILL BITS(21/32 IN).                       *
          *     CENTER PUNCH        PORTABLE DRILL MOTOR                        *
          *     SCRIBER             RATCHET?(1/2IN.DRIVE)                       *
          *     8' STEEL TAPE       EXTENSION 1/2 IN. DRIVE)                    *
          *     6" STEEL SCALE      SOCKET(15/16IN.)                            *
          *     MOLYCOTE COMPOUND COMBINATION WRENCH(15/16IN.)                  *
          *     C-CLAMP             PRE-MANUFACTURED TEMPLATE                   *
          *     CUTTING FLUID                                                   *
          *                                                                     *
          *                                                                     *
          * (B) TOOLS REQUIRED FOR INSTALLATION WHEN LINERS ARE                 *
          *     NECESSARY INCLUDE                                               *
          *                                                                     *
          *     ALL ITEMS LISTED UNDER (A)                                      *
          *     FILE                                                            *
          *     FEELER GAGE                                                     *
          ***********************************************************************
```

FIGURE 2 PRINTED TOOL LIST ON A BILL OF MATERIAL FORM

```
*****************************************************************************
* --- TIDB TEXT SYSTEM ---    DB81ING       DATE: 04/15/85    TIME: 13:45:18   *
*****************************************************************************
              BILL NUMBER: 0000-000-1     HULL: 4500
            SELECT OPTION: 1            ACTION: C
AVAILABLE OPTIONS:
        1. TEXT CREATE/MODIFY/DELETE
        2. DETAIL TEXT VIEW  ================>         TO
        3. MERGE PARAGRAPH FROM EXISTING BILL
        4. BILL PARAGRAPH LIST
        X. EXIT
AVAILABLE ACTIONS:      C.  CREATE     M.  MODIFY     D.  DELETE
     STATUS: 033-*** PLEASE ENTER THE REQUIRED INFORMATION ***
```

FIGURE 3 TIDB TEXT SYSTEM OPTIONS

CONCLUSION

In the environment of increasing competition, the U. S. shipbuilding industry must increase productivity in every phase of its operation. in its attempt to do this, the U. S. shipbuilding industry must include the industrial engineering techniques of methods analysis as a tool to reduce labor costs in the area of onboard ship construction.

The techniques of Methods analysis have been a proven producer of productivity improvement in the mass production environment over the years. This article has provided an actual application of this in the shipboard environment. Thus, shipyards should consider actively employing methods analysis with increased emphasis in onboard ship construction work on a continuing basis.

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LIST OF TABLES AND FIGURE CAPTIONS

TABLES

FIGURES

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